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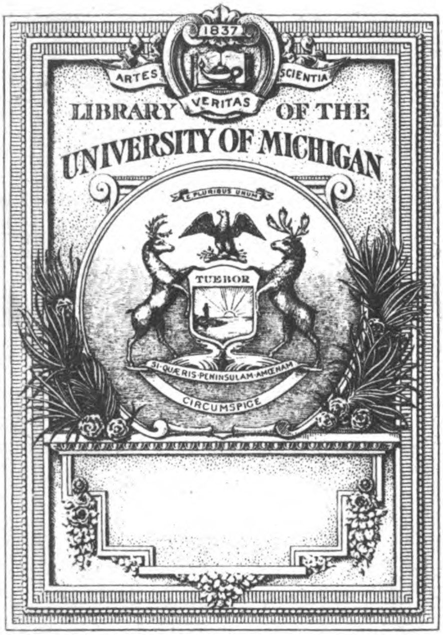
X-RAYS



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X-RAYS

1926
Eastman Kodak Company
Medical Division Rochester, N. Y.

INTRODUCTION

WHILE the average person who works with photographic films or plates has a general idea of their nature, there are few, probably, who know of just what such photographic materials are composed.

The modern film or dry plate consists of a layer, about one-thousandth of an inch thick, of gelatin containing a silver compound which is extremely sensitive to the action of light, coated on a glass or film support. This sensitive layer is called the "emulsion." It will be readily understood, then, from the delicate nature of both gelatin and the silver salt, that the photographic emulsion is very sensitive to treatment of any nature. When light, or x-rays, strike this sensitive surface, a change takes place. This change is too small to be measured by any known chemical or physical methods. However, by treating the layer with a chemical solution called developer, a chemical reaction takes place wherever this change has been produced, resulting in a deposition of silver, in tiny granules, from the silver compound, thus forming a metallic image. Such an image may be primarily formed by abrasion, by light, by x-rays, or by radium radiation. In such cases we get what is called a negative, that is, the portions that were light in the original are dark in the developed plate. On page 5 is reproduced a magnified section of such an image on film, showing the silver particles.

The amount of exposure necessary to bring about this result and the faithfulness of rendition of light and shade in the original, and freedom from accompanying defects, depend to a large extent on the quality of the emulsion.

The speed of a photographic film or plate to x-rays depends primarily on the absorption or stopping of the incident x-rays by the thin emulsion layer. To accomplish this, the nature of the sensitive emulsion must be radically changed from that which is used in ordinary photography. The aim has always been to obtain the maximum speed without sacrifice in quality, uniformity and keeping power.

X-ray emulsions, as perfected by the Eastman Kodak Company, have that happy balance of these characteristics—speed, quality, uniformity and freedom from defects—which stand for the highest efficiency in the various radiographic processes.

This emulsion, coated on transparent support, forms the well-known Eastman Dental X-ray Films. These combine the standard quality of the emulsion with the added factors of lightness, durability, convenience of storage and adaptability to Dental Radiography. A new emulsion is coated on both sides of the base to give the *Radia-Tized* Dental X-ray Films. This, too, is more constrasty than single coated film. Another emulsion is coated on both sides of a thin, transparent base, forming the Eastman Dupli-Tized X-ray Film. By this method of double coating not only is greatly increased speed obtained, but the developing time is shortened about 20% and the fixing time about 50%. Dupli-Tized Films also dry considerably faster than plates.

In making x-ray negatives, it is essential to use a material which will show the greatest difference in density or blackness with the slightest difference in exposure, for the tissues of the human body are in some cases nearly as opaque as the material of which it is desired to obtain an outline. It is also essential to use a material which can carry this process, of showing small exposure differences, over a wide range of transparencies in the same exposure; in other words, an x-ray film or plate must possess great power of contrast and at the same time be capable of showing fine gradation and detail in the developed image. These factors have been studied at great length in the Research Laboratories of the Eastman Kodak Company and as the result of these tests and investigations together with unequalled manufacturing conditions, the Eastman X-ray materials are as nearly perfect as it is possible to make them with the present day knowledge of physics, chemistry and mechanical processes.

EASTMAN KODAK COMPANY,

October, 1926 Rochester, N. Y.

Simple X-ray Photographic Physics

The Generation of X-rays

The manner in which x-rays are generated is a very complex physical process not as yet thoroughly understood. For the purposes, however, of practical roentgenology only a few simple laws governing the physics of x-ray generation are needed.

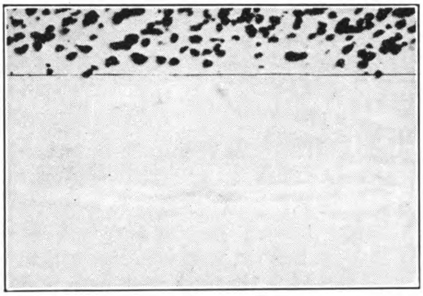

FIGURE I.

Magnified section of a developed image showing silver particles

An x-ray tube consists essentially of a thin walled glass bulb which is highly evacuated and into which have been sealed two electrodes or terminals. When a source of high voltage, such as an induction coil or transformer, is connected with these terminals, a curious phenomenon takes place. From the surface of the electrode, to which the negative wire of the high-potential generator has been connected, minute electric particles fly off at right angles to the surface of the electrode. This electrode is called the Cathode, and the particles, Cathode Rays or Electrons. If the cathode surface is shaped in the form of a concave mirror, it follows that these particles will be focused at the center of curvature of the mirror. A diagram illustrating the generation of cathode particles is shown in Fig. II. Here will also be seen the focusing caused by curving the cathode surface.

Whenever one of these cathode particles strikes the other electrode, which is called the target, an x-ray pulse is radiated in all directions from the spot struck and if a sufficient number of them strike the target, a continuous beam of x-rays is emitted. This is illustrated by the diagram in Fig. III.

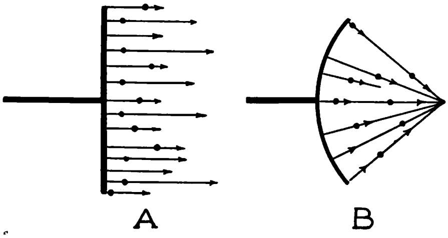

FIGURE II.

It is as though a piece of metal were struck rapidly by a hammer until it became white hot and radiated light. X-rays are not particles of matter as are the cathode rays, but are merely another form of ordinary light, which is of such high frequency of radiation that it penetrates objects which are quite opaque to ordinary light.

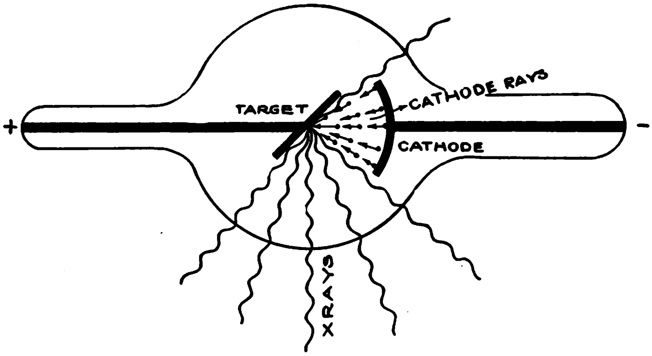

FIGURE III.

X-RAYS

The Factors Controlling the Generation of X-rays

The penetrating power of the x-rays generated increases as the speed at which the cathode particles strike the target increases and the speed of these particles, in turn, increases as the voltage applied to the tube increases and the amount of gas in the tube decreases.

The quantity of x-rays produced depends upon the quantity of cathode rays produced and this, in turn, depends upon the quantity of electricity. That is, the quality and intensity of x-rays will depend upon the voltage and current applied. These are the two prime factors governing the emission of x-rays by the tube. The voltage is a measure of the electrical pressure and has the familiar analogy of the pressure per square inch in a water main, while the current may be likened to the rate of flow in the main; thus, at a certain electrical pressure, or voltage, we may have a small current of electricity pass into the circuit or a large current, according to the resistance.

Current

The current, in an x-ray tube circuit, is measured by units called milli-amperes, which are one thousandths of an ampere, and is usually read directly from an instrument called a milli-ammeter wired in the circuit.

Voltage

The pressure or voltage can be measured by the distance which an electric spark will jump to short circuit the x-ray tube. It will take approximately twenty thousand volts to jump a gap of one inch between fairly sharp points. Other voltages will be indicated as follows:

35,000 volts to jump a gap of 2 inches
45,000 " " " " " " 3 "
55,000 " " " " " " 4 "
65,000 " " " " " " 5 "
70,000 " " " " " " 6 "

There is usually a voltmeter supplied with modern equipment, which reads the voltage or sometimes the spark gap directly. It is well, if possible, to check the readings of this instrument by the actual spark gap.

A conventional diagram illustrating an x-ray tube circuit showing control, high voltage generator, spark gap indicator, milli-ammeter and tube is shown in Fig. IV.

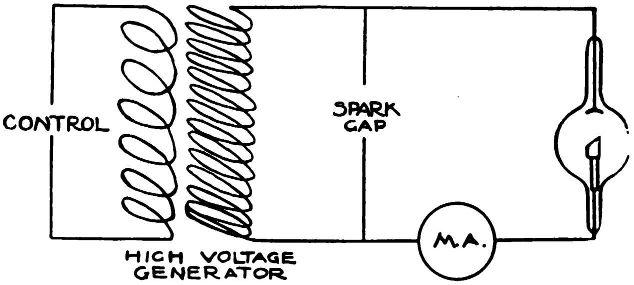

FIGURE IV.

The Statement of Exposure

The penetrating power of the resulting x-rays can thus be arbitrarily stated in terms of this spark gap, and the intensity or volume of x-rays of this penetrating quality stated in terms of the milli-ammeter reading. The quantity of x-rays can then be stated in terms of this spark gap, the milli-ammeter reading, and the time in seconds during which the x-rays are generated; that is, exposure may be stated in inches of spark gap, milli-amperes of current, and seconds of time.

The intensity, however, of x-rays has been found to vary inversely as the square of the distance from the target; thus if the distance is doubled, the intensity will be one-fourth, or if the distance is tripled, the intensity will be one-ninth of the intensity at the original distance; therefore, a complete expression of x-ray exposures may be given in terms of *inches of spark gap, milli-amperes of current, seconds of time and inches of distance;* or, working at the same spark gap and the same distance, exposure may be stated in terms of milliampere - seconds and time thus: E (exposure) = M. A. (milli-amperes) x S (seconds) = M. A. S.

It has been found that the reaction produced in a photographic plate by x-rays varies directly as the current and also directly as the time, that is, if either of these factors is increased, a proportionate increase takes place in the photographic reaction. For example, if for a given negative a correct result is obtained at a certain distance and a certain spark and in a certain time with ten milli-amperes of current, the time can be halved if the current in milli-amperes is doubled or twenty milli-amperes are used, and it may be cut to a quarter if the current is increased proportionately or forty milli-amperes are used. Similarily, if the time is doubled, the photographic exposure is doubled if the current is the same for both exposures.

Unfortunately, the photographic effect does not vary directly as the spark gap. This photographic variation has been determined for Eastman x-ray materials and it has been found most convenient to express the law in the form of a simple table, as follows: If with a given distance and current a certain photographic effect is produced with a three-inch spark in ten seconds (for example), the exposure times necessary to produce as nearly as possible the same effect for two, three, four, five, and six-inch sparks, are:

2″ spark—30 seconds
3″ “ 10 “
4″ “ 6 “
5″ “ 4 “
6″ “ 3 “

Influence of Spark Gap on Quality of Negative

It has been found that, other things being equal, the contrast in a photographic negative will decrease as the spark length increases. That is, the amount of difference in density which the negative will show with a slight increase of exposure is less for a six-inch spark than for a three-inch spark. This accounts for the brilliant negatives taken at shorter spark lengths where it is unnecessary to penetrate thick parts.

Since, however, this penetrating power is absolutely essential on thicker parts, there is a minimum spark gap which may be used with certain portions of the anatomy. The roentgenologist should include this factor in his exposure technique and use, for general work, a spark length which will yield x-rays of medium penetration. He will then secure negatives of proper contrast for most diagnoses.

The method of measuring the spark gap will greatly influence the value of the reading. It is suggested that the machine manufacturers' directions be carefully read and attention given to their recommended method of measuring voltage.

The Arithmetic of Exposure

A few illustrations of the variation of the photographic effect with variation of these factors—spark gap, distance, current and time—will show clearly how these oftentimes troublesome factors may be changed at will without any haphazard guessing. It is a matter of simple arithmetic.

Examples

1. Conditions:

Distance = 20 inches
M. A. = 20
Spark = 3 inches
Correct exposure time—12 seconds.

Query a: What will the exposure time be if the distance is changed to 15 inches and no other factors are changed?

Answer: The intensity varies inversely as the square of the distance, therefore, the relation of *exposure* times would be *directly* as the squares of the distances, thus:

$$12 \text{ sec.} : \text{unknown or “X”} :: 20^2 : 15^2$$

$$\frac{12}{X} = \frac{400}{225}$$

$$X = 6\tfrac{3}{4} \text{ seconds.}$$

The correct time at 15 inches is then 6¾ seconds.

Query b: What would be the correct exposure time if the distance were changed to 30 inches?

Answer: The same square law would apply.

$$\frac{12}{X} = \frac{20^2}{30^2}$$

$$\frac{12}{X} = \frac{400}{900}$$

$$X = 27$$

The correct exposure would then be 27 seconds.

2. Conditions same as in (1).

Query: What would be the correct exposure time if the current is doubled?

Answer: If the current is doubled the intensity of the rays is doubled, consequently the time necessary would only be one-half, that is, 6 seconds.

3. Conditions as in (1).

Query a: What would be the correct exposure time if the spark gap were changed to six inches?

Answer: If this were done, then the photographic intensity would change in the same proportions as the spark factors for 3″ and 6″ in the table on page 9.

Thus:

$$\frac{12 \text{ secs.}}{X} = \frac{10}{3}$$

$$X = 3.6 \text{ secs.}$$

The correct exposure time is then 3.6 seconds.

Query b: What would be the correct exposure time if the spark gap were changed to 4 inches?

Answer: The same relation as given above would hold.

Thus:

$$\frac{12 \text{ secs.}}{X} = \frac{10}{6}$$

$$X = 7.2 \text{ secs.}$$

or correct exposure time = 7.2 seconds.

The effect of varying any of these factors may be ascertained directly by use of the Eastman X-ray Exposure Rule (page 50).

In this rule these various factors are multiplied or divided automatically by merely making the settings as indicated. Being based on painstaking investigation and having been checked by prominent roentgenologists, it will indicate, for a given normal case, an exposure which will be approximately correct if the factors of spark gap, current and distance are known.

The operator should always strive to obtain full exposure, rather than under-exposure. It is a simple matter to develop an over-exposure, while an under-exposure is practically hopeless.

Theory of Shadow Formation

The general theory of radiography is quite simple, being merely the projection of radiation in the form of x-rays through the object in straight lines from the x-ray tube to the photographic plate. The mechanism of x-ray "picture" formation will probably be more clearly seen by illustrating a few elementary principles of shadow formation. If, as in

Fig. V-A, we have light from a source "A-B," falling on the point "O," then the shadow of "O" will be formed by a projection of straight lines from "A" through "O" and from "B" through "O." Now, if there is a screen of any sort placed just behind "O," as at "S" in the figure, the shadow will be sharpest and the nearest to the original size. As we move this screen further from "O," the shadow increases in size and loses its sharpness of outline, as depicted at "S_1" and "S_2." If, however, the light source "A-B", Fig. V-B, is moved further away from the object "O," then the straight lines through "O" from "A" and "B," determine new shadows on the screen, which are much nearer the original in size than was the case when the light was close.

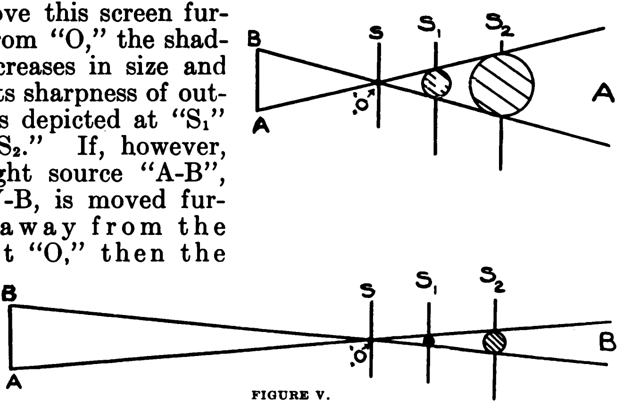

FIGURE V.

These same laws hold good in the case of x-ray shadow formation, with the difference that objects quite opaque to light will be relatively transparent to x-rays, allowing, as in the case of a radiograph of the arm, a clear shadow of the bones without interference from the flesh.

Sharpness of a radiographic negative is likewise determined by the nearness of the object to the plate (this takes the place of the screen in Fig. V.), by the nearness of the x-ray tube to the plate and by the narrowing of the beam by diaphragms.

The density produced in any part of such an x-ray negative will be further determined by the factors—voltage or spark gap, current in milli-amperes, seconds of exposure time, distance from tube to film and by transparency of the part of the object over that particular part of the film. The transparency to x-rays will decrease as the density of the object increases. Density here means the mass per unit volume, that is, grams per cubic centimeter.

Theory of Positioning

A further matter of elementary importance in making correct x-ray negatives is that of properly placing the object in reference to the direction of rays from the tube. Since it has been seen that the x-ray image is formed by the projection of x-rays through the object to the film, it follows that to minimize distortion, the rays should pass perpendicularly to the film, through the object, when in its normal position. However, in case it is not possible to fulfill this condition, the image can still be obtained, without distortion, by proper adjustment of the angle of the film. This is illustrated in Fig. VI: (*a*) shows the image of a circle formed in normal position; (*b*) shows the image distorted from a true circle to an ellipse when the object is not in a normal position: and (*c*) shows the circle projected in true form by adjusting the film angle to compensate for the object angle.

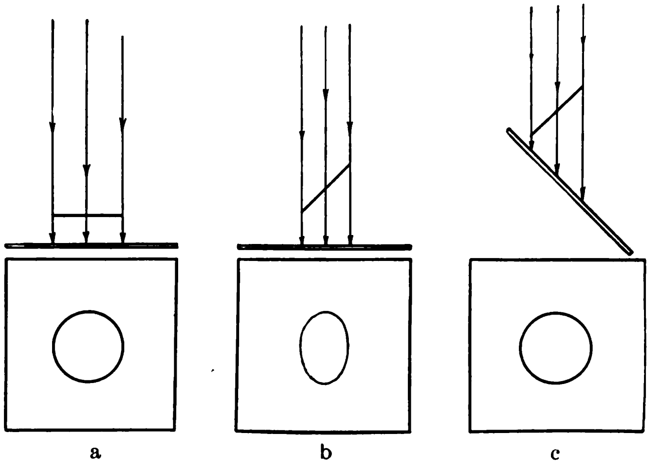

FIGURE VI.

The advantages of this will be seen later, particularly in taking dental radiographs, as it is not possible in a large percentage of cases to get normal positioning (see page 22).

Further X-ray Photographic Physics

Secondary Radiation

In the preceding chapter, it has been assumed that x-rays travel in straight lines from the target through the object to the photographic film. Were this absolutely true, we should be able to obtain sharp radiographs of any object, however thick, providing sufficient exposure is given. Unfortunately, there is a possibility of x-rays being deviated from the initial direction.

Scattered Radiation

When an incident beam of x-rays strikes an object, a portion passes through in straight lines. A considerable percentage, however, is scattered in all directions by the atoms composing the object struck. This phenomenon is very similar to the action of ordinary light striking ground glass. It may be demonstrated by a very simple experiment how the outline of the object is altogether lost if viewed through even a thin piece of ground glass. X-rays, after they are deflected from their path by the atoms of the object, are photographically of the same type as the original x-rays, and hence, cause a general haziness over the sharp outline formed by the rays passing through unscattered.

Diaphragms

To cut this scattering action down as far as possible, various methods may be adopted. The simplest general law is to use as narrow a beam of rays as possible in making the negative, so that the least volume of the object is encountered by x-rays.

Diaphragms for this are very essential and it is good practice to have the diaphragms as close to the object as possible.

Excellent diaphragms may be made by simply using sheets of lead having circular apertures of sizes adapted to the particular part rayed. One of these sheets may be laid directly over the part in question.

The importance of diaphragming is often neglected. It is a factor that, if properly considered, will bring negative quality from the ordinary to the exceptionally good.

There have been several types of special accessories designed to reduce the effect of scattered radiation, but none of these had been very effective until the recent introduction of what is known as the Potter-Bucky Diaphragm. This is a moving grid interposed between the part to be rayed and the sensitive material. The grid is composed of a series of thin parallel strips of lead with narrow spaces between, through which the rays are permitted to pass. These parallel strips have the function of absorbing the diverse rays which come from the tissues, so that the major portion of the image is formed by the primary rays from the focal spot of the tube. The movement of the grid is to eliminate the direct shadow of the grid structure.

Inasmuch as cutting out a great amount of scattered radiation results in longer exposures when using this type of grid, it is convenient to use intensifying screens for this kind of work.

The value of the Potter-Bucky Diaphragm over the use of small lead diaphragms is that it permits one to cover a large area of a thick part with a single exposure.

Characteristic Radiation

A further complication, which fortunately is not met with to any extent in average radiography, is due to the fact that when x-rays are absorbed by the atoms of a substance, they are under certain conditions emitted again as x-rays of a quality somewhat different from the original rays. This type of radiation is called "characteristic radiation" and usually takes place when x-rays of the average quality used strike one of the metals. Brass, iron or nickel are most likely to give rise to characteristic radiation which will generally cause trouble. The characteristic radiation from aluminum (which is widely used in radiographic appliances) is fortunately absorbed by the paper of the envelopes or containers of the films. The other metals mentioned should be kept out of range of the primary x-ray beam.

These two types—scattered radiation and characteristic radiation—are generally referred to as secondary radiation. As pointed out, the radiographer is concerned chiefly with scattered radiation.

In using thick wooden tables enough scattered radiation is returned to the film, in the case of direct exposures, to warrant interposing lead between the film and the table. Thin leadfoil gives sufficient protection against fogging from this cause. Metal backed exposure holders may be secured if desired (page 48).

The Coolidge Tube

In the elementary tube previously described, there must be a certain amount of gas left in it in order for it to operate. The type of x-ray tube invented by Dr. W. D. Coolidge, usually called the Coolidge Tube, is designed on a somewhat different principle. There are still the high potential current wires terminating in an evacuated tube at the cathode and at the target. The bulb, however, is completely evacuated so that the cathode will not liberate electrons under ordinary conditions. When this cathode, which is made in the form of a spiral of tungsten wire, is heated to incandescence by means of an outside source of electricity, it gives off cathode particles or electrons which are driven to the target by the high potential current. The quantity of these cathode particles will depend entirely upon the temperature of the wire and this temperature in turn will depend on the amount of electric current in this heating circuit. This current can be very conveniently measured by an ammeter wired in the circuit. The velocity of the cathode rays, and hence the quality of x-rays, will depend, as in the case of the gas tube, on the voltage applied. There being no gas pressure in the Coolidge Tube to fluctuate, it is constant under all conditions of voltage and current, is easily controlled and may be run for hours at a time.

The only limit to this production of x-rays is the limiting temperature at which the target will melt, due to the heat caused by the bombardment of cathode particles.

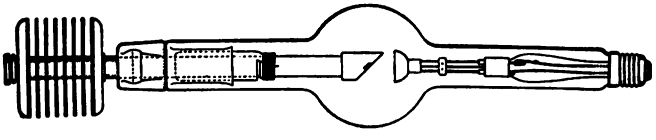

FIGURE VII.

During the war, further improvements were made in this tube by Dr. Coolidge, resulting in the Coolidge Radiator Type Tube, which is shown in Fig. VII. This type of tube is so designed as to rectify its own current, that is, it may be used directly on a transformer without the usual mechanical rectifier. Thus it has been possible to greatly economize on the cost of machine manufacture, resulting in the present small compact outfits with which this tube may be used. It has also been possible to greatly reduce the size of the focal spot in this type of tube, which has served to overcome the objection to the lack of definition attained with earlier tubes.

The type of x-rays coming from a Coolidge Tube and from a "gas" tube, under the same conditions of voltage and current, are identical; but as will be seen from the shadow diagram in Fig. V, page 12, the size of light source determines, to some extent, the sharpness of the shadow of an object. Similarly, the size of the spot on the target, from which x-rays originate, determines the sharpness, to a certain extent, of the x-ray image. This size of focal spot of any x-ray tube may be compensated for by placing the tube at a greater distance from the object, as follows from the shadow diagram in Fig. V.

The Intensifying Screen

When x-rays strike the emulsion of an x-ray film, less than 1% of their energy is absorbed, the remaining 99% passing through without performing any useful work. It is the absorption that governs the formation of the latent image. It is obvious, therefore, that if any method can be devised whereby the rays passing through the emulsion can be utilized, a decided advantage will be obtained in some classes of work.

It is well known that certain chemicals have the property of absorbing x-rays and emitting their energy as ordinary light. This property is called "fluorescence." Calcium tungstate, a white crystalline salt, has this property and has been used as a screen to place behind the photographic emulsion, absorbing the wasted x-rays and returning the emitted ordinary light back to the emulsion to intensify the photographic result.

The Eastman X-ray Intensifying Screen is made up of this fluorescent compound, finely powdered, held together with a suitable binder and coated in a thin, smooth layer on a light, flexible cellulose support.

In practice, the active face of the screen is put in direct contact with the emulsion face of the photographic film. The x-ray beam passes through the part of which a negative is desired, through the support of the photographic emulsion, and then to the screen. It follows then that some of the energy is absorbed in the emulsion but that the greater amount is absorbed by the intensifying screen, causing the negative image to be formed mainly by ordinary light from the screen. This light obeys all the laws of ordinary light and hence will not pass through opaque bodies as x-rays will. It follows that there must be no dust or dirt particles between the photographic emulsion and the intensifying screen; further, there must be no stain upon the screen for this will also absorb the ordinary light coming from it while it is fluorescing.

The exposure in the case of the intensifying screen is mostly on the emulsion surface. This fact must be taken into consideration in exposing and developing screen negatives, there being a general tendency to over-expose and under-develop such radiographs.

Cassettes

In actual use intensifying screens are mounted in rigid holders called cassettes, in order that perfect contact may be obtained between emulsion and screen. The average single intensifying screen used in a cassette increases the effective exposure about 300%. This factor, however, will vary somewhat with technique, particularly with variation of spark gap and with individual screens. These cassettes are strongly made so that they will stand considerable handling. Screens should always be stored apart from chemicals or other sources of contamination in the darkroom and the sensitive surface never touched with the fingers and only cleaned with a soft cloth or camel's hair brush.

Screen Efficiency

There will always be, with the present types of intensifying screens, a certain amount of graininess, due, in part, to the fluorescent layer being made up of fine particles. This graininess may be kept at a minimum by using, as far as possible, a moderate spark gap technique.

The graininess due to the screen itself, however, is usually of secondary importance, because much greater grain is caused by the scattering of the x-ray beam by the tissues of the thick parts for which screens are usually used. The greatest of all factors contributing to making screen negatives of poorer quality than direct negatives is "speckiness," caused by dirt particles on the screen surface. This is largely due to carelessness of the operator, for the present American-made screens are singularly free from such specks due to manufacture. Because of the waterproof protective layer of Eastman Intensifying Screens, this superficial dirt may be easily removed by simply washing.

Photographic Exposure Technique

Direct Exposure—Dupli-Tized Films

These films may be used for direct exposures of all types They should be loaded either in cassettes or in the Eastman X-ray Exposure Holders (page 48), never in envelopes.

In making direct exposures on a wooden table, it is suggested that lead backed holders be used.

In loading the holders it is also suggested that the black paper folders be left on the films, as in this way damage from finger marks will be greatly reduced.

Inasmuch as this material is coated on both sides of the support with sensitive emulsion, in all cases where it is important to determine the tube side of the negative afterward a lead marker should be used.

Direct Exposure—Plates

Eastman X-ray Plates may be used for direct exposures of all types where the factor of the glass support is not of moment and where there is no need to take advantage of the characteristic features of Dupli-Tized Films. They will require—all other things being equal—about 50% more exposure than Dupli-Tized Films.

Exposures should be made in the usual orange and black exposure envelopes or in cassettes.

Double. Screens

It has been demonstrated that using Dupli-Tized Film, with an intensifying screen on each side, yields a type of negative, when used in combination with the fine focus tube, that cannot be surpassed for contrast and brilliancy by any other method. The full actinic value of both screens is realized by the sensitive emulsion coating on both sides of the film support in a way that was not possible with single coated film or plates. Exposure is reduced to about one-half that with a single screen, and providing the screens are kept clean and free from spots, the primary graininess of the screen is not at all distinguishable. It is recommended that the front member of the screen combination should be of a special thinness. Eastman Intensifying Screens are designed to operate efficiently either as front or back screens.

In loading the cassette, the black paper covering each sheet of film should of course be removed; it is also important that good contact be had between screens and film over the entire surface.

By this method, negatives of excellent photographic quality may be obtained with short exposures even with units of the bedside and portable types. To reduce the increased exposure necessitated by the Bucky diaphragm, double screens are widely used. In this case, there being no pressure of the patient on the cassette, care should be exercised to see that film and screens are in good contact.

Double screen technique should never be attempted with plates.

Single Screen

It is of course possible to use a single intensifying screen with Dupli-Tized films in cases where the main consideration is reduction of exposure time. In this technique it is suggested that the screen be used back of the film.

Standardization

It is strongly urged that the routine processes of loading, positioning and exposure be standardized as far as possible. By so doing the undivided attention may be given to the "sizing up" of the particular part to be rayed.

The Use of Dental X-Ray Film

It is, perhaps, not too sweeping a statement to make that dental roentgenology is indispensable to dental science today. Furthermore, it has probably contributed more than any other single cause to the wonderful advance made in operative technique in the last five years, particularly in the treatment of dental abscesses.

One of the primary aids in this growth has been the dental film package designed for intra-oral radiography. With this film it is a comparatively easy matter to standardize exposure and developing technique so that the most important function of radiography—interpretation—is not dwarfed by processes which should be mechanical.

In the Research Laboratories of the Eastman Kodak Company experimental work is constantly going on to improve the technical accessories of dental radiography, and to study the photographic problems involved.

As this research develops, improvements, new products and methods are made available. Thus, while still continuing the standard dental film types "Regular" and "Extra Fast" (in use for many years) there was added a distinctly new dental film "*Radia-Tized*"—a double-coated film designed especially for dental radiography. Thus too, in collaboration with Dr. Howard R. Raper, the "*Bite-Wing*" * film was developed—a film which we feel will revolutionize present possibilities in preventive dentistry.

While dental radiography is simple in so far as exposure calculations and developing procedure go, it is a very exacting science, demanding careful study to obtain uniformly good results. This is chiefly due to the necessity for correct positioning, in order to secure the entire tooth and at the same time avoid distortion. The difficulty of this procedure is further complicated by the extreme variations in the contours of the maxillae of individuals.

Getting the Correct Angle

In taking the dental radiograph, the position of the film with reference to the position of the tooth is necessarily fixed, for it is conditioned by the conformation of the mouth of the individual, that is, the angle between the tooth and the

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**A full exposition of this new method and its possibilities is given in a booklet prepared under the supervision of Dr. Raper. This is sent free on request.*

film is definitely fixed. The theory involved then, in correctly positioning the tube in order to keep distortion at a minimum and at the same time obtain a clear delineation of the tooth, is one of simple projection, for the proper tube angle is conditioned by the angle between the tooth and the film. This will be more clearly seen by a study of the diagrams in Figure VIII. The tube should always be so adjusted that the central ray is perpendicular to a plane which bisects the angle between the tooth and the film. Distortion will then always be at a minimum. The central ray, of course should pass through the center of the area of which a radiograph is desired.

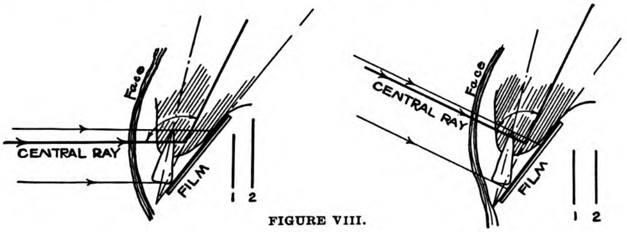


FIGURE VIII.

INCORRECT

CORRECT

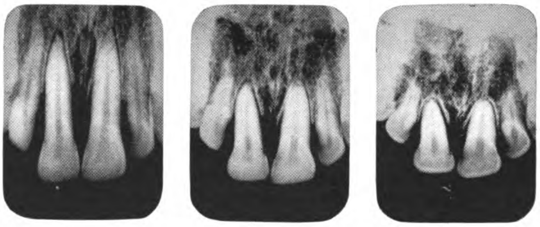


FIGURE VIII*a*.

The illustrations in Figure VIII*a* show the effect of tube angle in actual dental negatives. The angle in making the central negative is correct, while the others are incorrect, one resulting in elongation and the other in foreshortening.

Placing the Film

While there are several appliances on the market to hold the film in the patient's mouth while exposures are being made, it will probably be found sooner or later by the dental radiographer that the best method is still the simplest method of all—that is, for the patient to hold the film in place with the thumb or finger. The film should first be carefully placed by the radiographer, who should demonstrate the desired amount of pressure with which the package should be held in place, cautioning against movement, either of the head or of the film itself in the mouth.

The exposure will depend upon the speed of the particular film used and the other factors described in the preceding chapters. It is desirable here, as elsewhere, to use a standard spark length if feasible. This should generally be about three or four inches. This technique will yield contrasty negatives but with good detail.

Most dental x-ray equipments, however, function at a fixed current, spark gap and distance—conditions under which the average exposure time for teeth is about 2½ seconds for *Radia-Tized*, 1¼ seconds for Extra Fast and 5 seconds for Regular Eastman Dental X-ray Films. All of these materials, when properly exposed and developed, will yield negatives of high quality. For all-around adaptability, though, the *Radia-Tized* film is strongly urged. In taking upper molars it is advisable to expose about 25% longer than for the rest of the teeth.

After the exposure has been made, development should proceed under the same technique as described on pages 31 to 39. For facilitating convenience in handling, various sundries are on the market. Several of these are listed at the end of this booklet. With these accessories, it is possible to make the development of dental radiographs a simple routine matter if proper regard has been given to the importance of the process from the very beginning. Poor negatives in dental radiography may be mostly charged to lack of appreciation of the photographic factors involved. A precaution often neglected, which results in the loss of a good many negatives, is that of providing a safe storage place for dental films. The Eastman Dental Film Safe has been designed to provide a convenient cabinet for this purpose.

By tank development and the use of a Dental Film Hanger, individual cases may be kept together until dry when they may be marked with some distinguishing number or, if preferred, individual cases may be identified by writing some distinguishing number on the packages at the time of exposure. The "C" packages are readily adapted to this method.

In the rapid expansion of dental roentgenology it has been impossible, in the case of many dentists with offices in down-town office buildings, to make provision for a darkroom. The Eastman Dental Film Developing Cabinet has been designed to meet this situation. This Cabinet is, in fact, a complete miniature darkroom with tank development, safelight and provision for circulating water.

The tank unit alone (page 51) offers a simple means of efficient tank development where a darkroom is available.

It is not necessary, usually, to mark the film with reference to the region of the mouth radiographed, as a skilled operator will quickly determine the dental region by orientation of the image in the negative, bearing in mind that the emulsion side faces the tube during exposure.

It is common practice to insert individual dental films in some type of mount, to permit of easy filing, handling and viewing. The Eastman Dental Film Mounts have been devised to furnish a convenient means of meeting these requirements.

Standardizing Procedure

Summarized, then, the method which, if followed, tends to produce uniformly good dental negatives is:

1. Correct positioning.
2. Uniform exposure technique (standard spark gap, current and tube distance).
3. Development for five minutes at 65° in recommended formula.
4. Cleanliness in manipulation.

Darkroom Procedure

Darkroom Design

The three prime causes of trouble to be avoided in the darkroom are: (1) unsafe lighting, (2) contamination, and (3) careless manipulation. The first is, perhaps, the easiest to remedy. After the room to be used for the darkroom has been selected, the operator should test it for the presence of stray light by remaining inside the darkened room about five minutes (until his eyes acquire their maximum sensibility). He will then be able to note any holes where light is leaking in. These should be stopped up carefully. If possible, an entrance should be arranged with double doors, double curtains or some similar "light lock" (see Fig. IX*a*), so that entrance or exit may be made without allowing outside light to enter. In case such an arrangement is impossible, a lock should be put on the inside of the door to prevent an outsider suddenly opening it and possibly spoiling sensitive material.

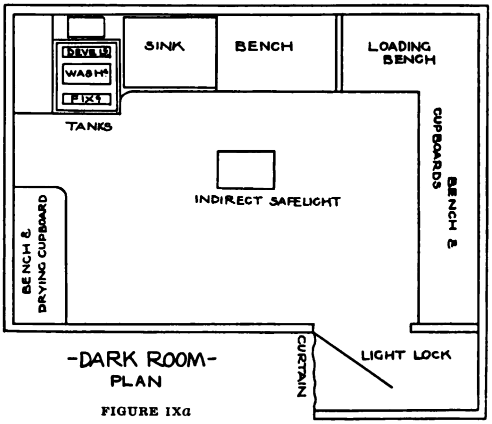


FIGURE IX*a*

Illumination

The room should then be illuminated by light of a photographically safe quality. For a safelight of moderate cost, the Brownie Safelight Lamp or the Eastman Safelight Lamp is ideal for the small darkroom. For larger rooms the Kodak Safelight Lamp or the Wratten Safelight Lamp can be used. Series 2 (red) or series 4 (green) safelights are recommended for x-ray work. Any of these lamps will provide ample illumination of safe quality provided the proper wattage lamp is used. For the average darkroom, using the Wratten Safelight Lamp, a 25-watt Mazda lamp will be satisfactory.

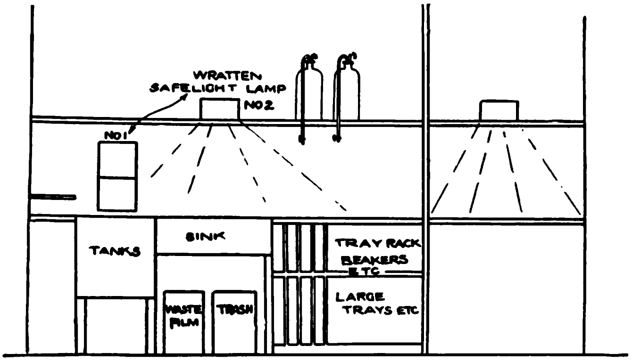


FIGURE IX*b*

It is well, in so far as possible, to have the general illumination of the room indirect. This can be accomplished by suspending a Wratten Indirect Light-Box from the ceiling so that the light is reflected from the ceiling and walls.

With the lamps previously mentioned the walls and ceiling may be painted some light color, as for instance a buff in the case of red illumination, or a light sage green in the case of green illumination. These colors have high reflecting power and a pleasing appearance when the room is illuminated by white light.

A simple method of checking the safety of illumination is to expose a fast dental film or a piece of Dupli-Tized film for varying lengths of time in the place where films will be mainly exposed in handling and developing, and give this sample standard development. If no fog shows with a reasonably long exposure, the lighting may be assumed to be safe.

For any darkroom, running water should be accessible, and where tray development is employed there should be a convenient bench for the manipulation of trays containing developer, wash water and fixing bath. This bench should be placed where the illumination is good but safe. For a larger darkroom or for an operator who does a moderate amount of work, tank development is to be recommended.

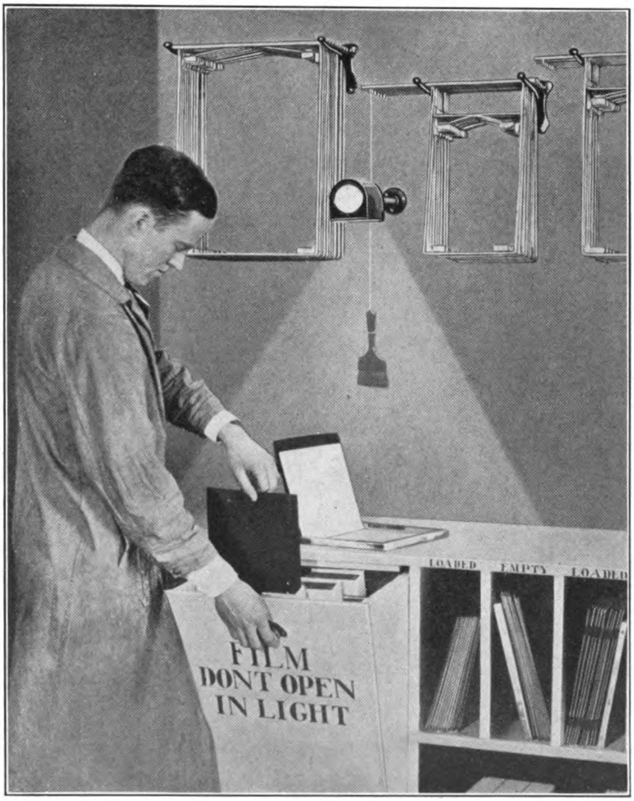


FIGURE X.

Storage of Materials

Trays, beakers and graduates should be conveniently located on proper racks and the sink designed to give the maximum convenience. The developing section of the darkroom should be kept separate, as far as possible, from the section devoted to the storage of plates, films and loading of holders. The films should be kept in a cool, dry place, protected from any such disturbing factors as action of chemical fumes, dust, light and x-rays. A very effective means of storing films so that they are readily accessible

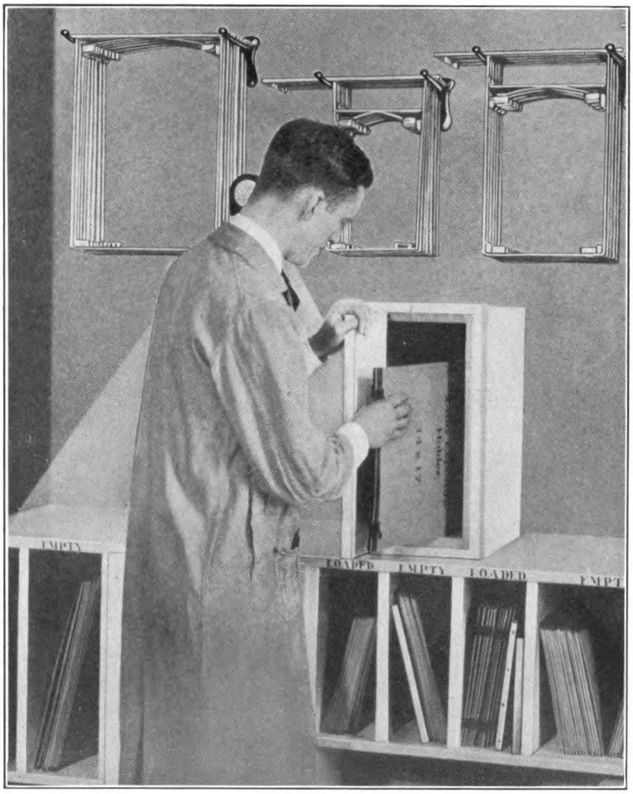


FIGURE XI.

is provided by a film bin similar to that shown in Figure X. Such a bin can easily be made by the carpenter when the darkroom is being finished. If, in addition to this bin, a small hinged opening is put in to pass films through to the operating room, the work is greatly facilitated. This is shown in Figure XI. If this latter device is lead-lined the necessity of a lead chest in the operating room will be obviated. Where extremely penetrating radiation is in general use for long times, as in the case of deep therapy, special precautions should be taken to insure protection of sensitive materials both from x-rays and radium. The photographic chemicals should also be stored in air-tight containers in a dry place.

The darkroom should be, at all times, a model of cleanliness. Developer or hypo spilt on the floor should be quickly mopped up. If it is left to dry on the floor, it will float about with the dust in the room and settle on plates and films, causing spots to appear when they are developed.

Loading Containers

In loading plates and films, the operation should be confined to as few movements as possible. The emulsion should never be touched with the fingers if they are at all moist, as such an imprint will develop up in the finished negative. Care should be exercised also to avoid scratching or in any way marring the emulsion surface. In the case of films, they should be handled in such a manner that they are never crumpled before development.

With these precautions observed, the average darkroom operator should have few films or plates spoiled by markings either from careless manipulation or from contamination at any stage in their handling. In Fig. IX*a* and *b*, sketches of a model darkroom for the average worker are shown. This, of course, may be modified to suit the available space.

Design of Developing Tank

For tank development, the "unit" system of tank manipulation is suggested. In this method a sink is so arranged that it may be filled with circulating water. Preferably, provision should be made for maintaining this water—by combination hot and cold water faucets or ice—at the desired temperature. Removable tanks are then introduced to hold developer and fixing solutions. A number of these "unit" tanks should be on hand so that fresh solutions may be made up at any time without interrupting the routine developments. When these are ready, they can be substituted for the exhausted units. By this method developer, wash water and fixing bath are maintained at the same temperature (which is very desirable), and the replacing of exhausted solutions can be done with minimum inconvenience.

This method permits easy cooling of solutions in hot weather. Where the temperature of the water is always cold, it may not be advisable to have the circulating water bath. An extra tank may be used for washing, or a simple wooden frame built in to hold the film hangers during this process, if the sink is deep enough.

If washing is done in a tank "unit" the sink need not necessarily be of the depth of the tanks. Water to the depth of six inches will be sufficient to maintain temperatures.

Stone compartment tanks are obtainable for this type of development, and where they can be permanently installed in a laboratory, provide a neat and efficient means of handling large quantities of plates or films. Tanks of this type should have air space between the wash water and developing solutions, if control of temperature is a considerable factor.

A very serviceable tank system of this sort can also be made of stout wood lined with sheet lead. Such a tank can be made locally of any desired size or design, to fit conditions, to take any number of tank "units."

Developing Procedure

General Precautions

Development is rarely considered as the serious chemical reaction that it really is. The transformation of the photographic image to a silver deposit giving the finished image, is a process of extreme delicacy. There is the utmost need of cleanliness, as with any other delicate chemical reaction, if results are to be repeated with uniformity from time to time. There should be a constant condition of temperature, purity of chemicals and precision of timing.

To eliminate difficulties in development so that the operator does not have to be a trained chemist to obtain good results, the Eastman Kodak Company has prepared developing chemicals which are of the proper purity and have been precisely tested by expert chemists. These may be mixed properly by anyone if a simple direction sheet is followed. For anyone who wishes to mix developing solutions with the minimum of trouble and expense, the prepared X-ray Developing Powders are the simplest form in which to buy these chemicals. In these the necessary ingredients are weighed in their proper ratios to one another, ready to mix with water. X-ray Fixing Powders may also be obtained ready for dilution with water.

It should be borne constantly in mind that development and fixation of photographic films are chemical processes. Hence it follows that the developing and fixing solutions become exhausted slowly, due to the useful chemicals being converted to useless by-products. It is a very inefficient policy to use a developing solution after it is so exhausted by use or exposure to air that development is appreciably prolonged. Furthermore, the quality of the negative obtained by forced development in a stale, worn-out solution, is generally poor.

If tray development is used, just sufficient stock solution to complete the work in hand should be used and then thrown away. In tank development, the developer is in such large excess that exhaustion is slow, if the tanks are kept covered.

Tray Development

For tray development, at least sufficient developer to cover the film to the depth of half an inch should be used. The film is placed in the tray and the developer poured in quickly with a sweeping motion from one corner. At the same time the tray should be tilted so as to spread the developer over the entire surface without a pause in its flow. In developing Eastman Dupli-Tized X-ray Film, which is coated on both sides, convenience of manipulation may be increased by attaching a dental film clip to one end. Developer already being in the tray, the film is immersed by a quick sliding motion, without pause; after a few seconds it should be reversed. If the emulsion is not evenly covered, a dark line will show in the negative where the developer paused for an instant. Likewise, spattered drops, which strike the dry emulsion, will develop as dark spots.

Tank Development

Developer for the tank should be, in the case of x-ray materials, of the same concentration as that used for tray development. It will keep much longer if used in this form. There should always be sufficient developer in the tank to completely cover the plates or films.

Tank development of films with Film Hangers is a simple process. After the developer has been adjusted to the proper temperature, these film hangers are merely dropped into the tank, end on, and left for a predetermined time, five minutes, at 65°. They are then rinsed 5 to 10 seconds in the second tank, the washing tank, which should, if possible, contain running water. The solutions in all the compartments should be as near the same temperature as possible.

Time-Temperature Development

The temperature of the developing solutions, whether in the case of tray or tank development, should never exceed 70° F. and should, if possible, be about 65° F. Lower temperature will merely prolong development, but higher temperature will not only destroy quality but soften the emulsion to the extent of washing if off the support. If, however, conditions are such that temperature cannot be controlled and it is a question of being obliged to get the maximum quality out of exposures, the Time-Temperature Chart (facing page 60) will be found useful. This chart shows the variation of proper developing time as temperature changes, and is specially computed for Eastman Dupli-Tized and Dental films with Eastman X-ray Developer Powders.

Influence of Development on Quality of Negative

The variation of quality in the photographic negative with the exposure factors is very noticeable. It can be readily seen, if standard development is given, just what the trouble with the exposure has been. For instance, if the film has been over-exposed the image will have flashed up very quickly in development and the finished negative will be so dense as not to permit of seeing through even the lighter portions. There is no fine detail and contrast.

Over-development of a normal exposure will also choke up the fine detail in the lighter portions of the negative. These two factors will be sufficient to cover most of the difficulty experienced in regulating exposure and development; for, an under-exposed negative which has been over-developed will present the same choked condition of the highlights, while an over-exposed and over-developed negative will be both dense and choked in the highlights.

For the development of over-exposures it is most satisfactory to shorten the time of development from the normal. The use of a separate developing formula with an increase of restraining agent, such as Potassium Bromide, is not at all convenient to the average roentgenologist.

Judging Development

It is strongly recommended that development be kept mechanical, for while a sense of judgment may be developed as to when a negative is "right," on the average such results do not compare with those obtained by insisting on development for a predetermined time.

Importance of Rinsing

After development rinse the films for five to ten seconds in the wash tank. When a film is transferred from the developer directly to the fixing bath, the alkali in the developer retained by the film neutralizes some of the acid in the fixing bath. After a certain quantity of acid has been neutralized in this way, the balance of the bath is destroyed and its usefulness greatly impaired; stain is liable to be produced and the hardening action is destroyed. Therefore, by removing as much developer as possible from the film through rinsing before fixing, the useful life of the fixing bath is greatly prolonged.

Fixing

Eastman X-ray Fixing Powders or Formulas F-1 or F-1b, given on pages 38 and 39, are suitable fixing baths.

Fixing should be prolonged twice the time necessary to remove all visible trace of the opalescent silver salt. Films should be agitated on first immersing in the fixing bath and once or twice during fixation to insure even and complete action. In order to produce *maximum* hardening the thorough rinse, previously mentioned, should be given and then the films should be fixed for from fifteen to twenty minutes in the fixing bath. To maintain hardening the fixing bath should be acid in reaction. This can be conveniently tested by the use of litmus paper. Red litmus paper will remain red in an acid bath and turn blue when the bath becomes alkaline, when the solution should be discarded.

The Life of the Fixing Bath

A fixing bath is exhausted either when a sludge forms or when the fixing power of the hypo has been diminished to such an extent that there is danger of the unfixed silver salt remaining in the film after prolonged fixing.

For practical work some consider that the usefulness of a fixing bath has come to an end when it takes eight or ten minutes to remove the silver salt. An exhausted bath should be replaced by an entirely fresh solution. Under no circumstances should an old bath be renewed by adding hypo to it.

Eastman X-ray Fixing Powders, or Formulas F-1 or F-1b, will fix the equivalent of seventy-five 8 x 10 films per gallon of solution, provided a thorough rinse of about ten seconds precedes fixation.

During hot weather when it is necessary to secure maximum hardening action, a different technic is needed as discussed under "Processing X-ray Films Under Hot Weather Conditions," page 40.

Washing

X-ray films should be washed in running water which is so circulated that all parts of all the plates or films being washed, receive a change of water. Under such conditions washing should be completed in from fifteen to thirty minutes.

Following these directions, that is, development at the proper temperature in a correct developer, rinsing before fixing, complete fixing in a vigorous fixing bath and thorough washing after fixing, all negatives should be of good quality if properly exposed.

Markings

Defects, spots and markings of many kinds may occur if these rules are greatly departed from. For example, if washing between development and fixation is omitted, a chemical action will usually take place between the developer in the film and the fixing bath, resulting in a colored stain, which is red by transmitted light and green by reflected light. This is one of the most troublesome stains encountered in radiographic negatives. It may also be due to a combination of lack of rinsing and a weak, stale fixing bath which has lost its acidity, or to forced development and prolonged fixing with a stale bath. It will never be encountered if the rules laid down are followed. Other characteristic markings are dark spots caused by the spattering of developer as previously cited, dark lines showing spread of developer over the film either in the tray or by hesitating while sliding the film in the tank, and finger marks. A further trouble—fog—that is, a development of a silver image other than that conditioned by the exposure, is due to light leak, x-rays, improper development, or materials which have been kept under bad storage conditions or beyond a reasonable time.

By far the greatest source of annoyance and the one most common is x-ray fog, for in the rapid increase in x-ray exposure and intensity due to therapy many neglect the adding of enough lead protection. Cases have been found of films being fogged through 1/8" of lead in rooms fifty feet or more from the treatment tube.

Drying of Films

It is recommended that Eastman Dupli-Tized Films be dried in the developing hangers where possible. This will insure flat, evenly dried negatives. A convenient rack for holding film developing hangers during drying is made by drilling a 1x4 inch board, the holes being 2 inches apart and large enough to take the handle of the film hanger. Such a rack can be placed high on the wall so that there is no danger of striking the films while they are wet. If hangers are not part of the equipment the films may be hung by clips or pins from a projecting shelf or a line of wire or cord. Care should be exercised that neither surface of the film comes in contact with any object during drying.

Water drops must not be spattered on the drying emulsion surface, as spots will be produced which it is impossible to remove. Negatives will dry best in a warm, dry atmosphere where the air is changing. Temperature over 90° F. should be avoided. It will be found that Eastman Dupli-Tized Film negatives will dry considerably faster than glass plate negatives.

Developers and Fixing Baths

The best results can be obtained only through the use of chemicals that are pure and uniform. Eastman Tested Chemicals have maintained a reputation for both these qualities and are splendidly adapted to the sensitized product with which they are to be used.

Eastman X-ray Developing Powders

For the convenience of the roentgenologist Eastman X-ray Developing Powders have been prepared. These powders are intended for exclusive use with x-ray films. When mixed with water as recommended they give an Elon-Hydroquinone formula which is the equal of any standard Elon formula. The cost is practically the same as that of the combined chemicals contained, with the added convenience and assurance of the correct amount of each ingredient without any waste.

No. 2 Package contains six pairs of powders, each pair sufficient to make twelve ounces of solution.

No. 3 Single powders for tank use, sufficient to make 128 ounces (about one gallon) of solution.

No. 4 For tank use, sufficient to make up five gallons of solution.

Mixing Developing Solutions

If the roentgenologist desires to make up his own solutions, there are a few simple rules to follow which will assure him correct chemical reactions and reduce faulty technique to a minimum.

For the development of x-ray negatives, an ElonHydroquinone formula is recommended. A standard formula is given on pages 37 and 38 in quantities adapted to tray and tank use. These formulas are given in both avoirdupois and metric systems in as nearly equivalent quantities as possible.

When procurable, distilled water should be used in mixing all solutions. With hard water a precipitate of calcium carbonate will form in a developer but this will do no harm providing the solution is allowed to settle in a separate vessel and only the clear liquid drawn off for use. In mixing the Elon-Hydroquinone formula, the following procedure should be followed:

After the individual chemicals are carefully weighed out on small pieces of clean paper, they should be individually dissolved in as small an amount of hot water as possible. Before dissolving the Elon and Hydroquinone, a small amount of the sulphite should be mixed with them loosely while dry. This will prevent oxidation when water is added. After the ingredients are dissolved in a small amount of water, they are mixed together in the following manner:

(1) Pour together the solutions of the two developing agents.

(2) Pour together the two soda solutions;

(3) Add the Potassium Bromide solution to the solution of sodas;

(4) Add the developing solution to the solution of sodas and bromide.

This gives a small amount of concentrated developer to which the remaining amount of cold water is added, producing at the end of the operation a comparatively cool developer.

DEVELOPING FORMULAS

Elon-Hydroquinone Tray Formula

(Formula D-19)

	Avoirdupois	Metric
Hot water (about 125° F.)	16 ozs.	500 cc.
Elon	35 grains	2.4 grams
Sodium Sulphite (E. K. Co.)	3½ ozs.	105 grams
Hydroquinone	140 grains	9.6 grams
Sodium Carbonate (E. K. Co.)	1¾ ozs.	52 grams
Potassium Bromide	90 grains	6.2 grams
Cold water to make	32 ozs.	1 liter

ELON-HYDROQUINONE TANK FORMULA

(This formula is a multiple of D-19)

	Avoirdupois		Metric	
Hot water (about 125° F.)	2	gallons	8	liters
Elon	2	ozs.	60	grams
Sodium Sulphite (E. K. Co.)	84	ozs.	2500	grams
Hydroquinone	8	ozs.	240	grams
Sodium Carbonate (E. K. Co.)	42	ozs.	1250	grams
Potassium Bromide	4½	ozs.	135	grams
Cold water to make	6	gallons	24	liters

Preparing Fixing Bath Formulas

On the following page, formulas are given for both tank and tray size. These are acid fixing baths which have a decided hardening action on the gelatin.

For best results and stainless films the fixing bath should always be acid in action. This can be easily tested with litmus paper. Thorough rinsing as discussed on page 33 will assist in keeping the bath acid throughout its useful life.

For convenience in obtaining a fixing bath of vigorous action the Eastman X-ray Fixing Powders are recommended. For those wishing to mix their own fixing bath, the following formulas are recommended.

FIXING BATH FORMULAS

Acid Fixing Bath (Formula F-1)

(SMALL TANK OR TRAY)

	Avoirdupois		Metric
Water	64	ounces	2 liters
Hypo	16	ounces	450 grams
When fully dissolved add the following hardening solution:			
Water	5	ounces	150 cc.
Sodium Sulphite (E. K. Co.)	1	ounce	30 grams
*Acetic Acid (28% pure)	3	ounces	90 cc.
Potassium Alum	1	ounce	30 grams

Dissolve in the order given.

*The acetic acid is given in liquid ounces and cubic centimeters. To make 28% acetic acid from glacial acetic, take 3 parts of glacial and add 8 parts of water.

Acid Fixing Bath (Formula F-1b)

(TANK)

	Avoirdupois	Metric
Hypo	12 pounds	5½ kg.
Water to make	4 gallons	16 liters
When fully dissolved add the following hardening solution:		
Water	1 gallon	4 liters
Sodium Sulphite (E. K. Co.)	10 ounces	300 grams
*Acetic Acid (28%pure) (E. K. Co.)	30 ounces	900 cc.
Potassium Alum	10 ounces	300 grams
Cold water to make	2 gallons	8 liters

*The acetic acid is given in liquid ounces and cubic centimeters. To make 28% acetic acid from glacial acetic, take 3 parts of glacial and add 8 parts of water.

NOTE: If a more rapid fixing bath is desired, the hypo quantities in the above formula may be increased from 12 to 16 lbs. (5½ to 7½ kg.)

To make up the hardener solution, dissolve the chemicals in water at about 125° F. in the order given. The sodium sulphite should be completely dissolved before adding the acetic acid. After the sulphite-acid solution has been thoroughly mixed add the alum and stir until a clear solution is obtained.

When the hardener has cooled, add the solution slowly, with stirring to the cool hypo solution. The hypo should be thoroughly dissolved before adding the hardener, otherwise a pale yellow precipitate of sulphur is likely to form.

Reduction

While it is not generally feasible to attempt to improve the quality of a faulty negative by treatment after development, a case occasionally arises where such a process is very desirable to remedy the result of over-exposure.

This may be done satisfactorily within certain limits by correct chemical processes of reducing the densities of the silver deposit in the image.

The simplest method of reducing the density of an image in a dense negative is by the use of Eastman Reducer a prepared powder which is listed on page 61. The action of this in solution, to attack the metallic silver resulting in an image of less density. The negative should be free from contaminating chemicals before the process is begun. It is then quickly placed in the solution and the process of reduction watched until the proper thinness is reached. The action should be watched carefully or the operation is likely to be overdone.

If desired the reducing solution may be prepared, using the following formula:

Farmer's Reducer (Formula R-4)

SOLUTION A

	Avoirdupois	Metric
Hypo	1 ounce	30 grams
Water	32 ounces	1 liter

SOLUTION B

Potassium Ferricyanide . . .	15 grains	1 gram
Water	1 ounce	30 cc.

Mix together solutions A and B and pour over negative to be reduced.

After reduction the negative must be thoroughly washed to remove all traces of hypo.

Processing X-ray Films Under Hot Weather Conditions

Hot weather may add considerably to the difficulty of making good x-ray negatives unless all solutions are kept at a temperature of 65 to 70° F. The principal trouble is reticulation which is the formation of a network of fine lines, giving a very grainy appearance to the dry film, resulting from excessive swelling and softening of the emulsion coupled with the effects of the chemicals involved in the various developing and fixing reactions. The softened gelatin is also susceptible to damage by handling. The simplest and best remedy is to cool the solutions artifically so that developing and fixing are carried out at a temperature of 65° F.

If the means of cooling the solution is not effective and the wash water is still at a temperature of above 80° F. the gelatin should be hardened by treating with a separate hardening bath or in a combined hardening and fixing bath. This will prevent undue swelling of the emulsion.

As a last resort if for any reason these steps can not be taken, it is possible by special procedure to 'develop x-ray negatives of diagnostic qualities at temperatures from 80°

to 95° F. It should be emphasized, however, that this is a last resort, and is not recommended for use under other conditions.

This so-called tropical method of finishing consists in developing for a short time only and using a special hardening solution between developing and fixing. This hardening bath is supplied in ready-to-mix form in gallon size packages as the Eastman X-ray Hardening Powders. The time of development should be kept at two minutes and exposures adjusted as nearly as possible to give the correct density radiographs at this development time. After development rinse the films for one to two seconds with water not over 90° F. and transfer to a solution of the Eastman X-ray Hardening Powders or the following hardening bath.

Hardening bath formula SB-4

	Avoirdupois	Metric
Hot water (about 125° F.) . .	64 ozs.	2 liters
Potassium Chrom Alum . . .	4 ozs.	120 grams
Sodium sulphate, crystals . .	16 ozs.	480 grams
Cold water to make	1 gal.	1 liter

If any scum appears on the surface after mixing remove by skimming. This formula can, of course, be made up in any quantity by using proportional amounts.

When first put in this hardening bath the films should be agitated for about 45 seconds or streaking will occur. They should then be left in the bath for a total time of three minutes, then fix the films in baths recommended on pages 38 and 39 for twice the time required for opalescence to disappear, and wash for 15 to 30 minutes in running water not over 100° F. Before drying, both sides of the film should be mopped with absorbent cotton to remove any possible scum adhering to the surface.

The hardening solution is violet-blue in color by artificial light when freshly mixed, but it turns yellow-green when exhausted and must then be replaced with a fresh bath.

It is important in this method to keep all solutions as nearly as possible the same temperature or the gelatin will still be damaged when transferred from one solution to another. The solutions need not be cooled below 90° F. and after fixation washing may be carried out at temperatures of 100° F.

The hardening solution just referred to must be used as a separate solution and not mixed with the fixing bath, since separately it will maintain the facility to harden for many days, but mixed with hypo it loses its hardening powers after 24 hours whether the bath is used or not.

As previously mentioned this method is not recommended for general use and should only be employed when all methods of cooling the solutions such as the use of ice, electrical refrigeration or city water fail.

The Examination of Negatives

When possible to avoid it, films or plates should never be examined at any length until dry. Such handling, even by an experienced worker, is bound to mar the negative more or less. There is also very real danger of melting the gelatin of the emulsion when the negative is viewed in the average viewing box or frame.

Theoretical Considerations

There are two optical conditions which should be satisfied to make an illuminator satisfactory for viewing x-ray negatives. The first is that the light, striking the negatives, should be evenly diffused and of uniform quality, and the second is that the intensity of the light transmitted by the thinnest portion of the negative should not be so great that the eye is hindered in discriminating detail.

Viewing Frames

The first condition may be satisfied in a number of ways. The usual method is to place directly behind the negative a sheet of diffusing glass such as flashed opal glass or the usual ground glass, the illumination being usually furnished by tungsten lamps. Type C-2 Mazda lamps, with blue glass bulbs, are excellent lighting units. For frames where a number of large films are to be viewed and where diffusing glass is a considerable expense, a satisfactory arrangement can be made by an indirect lighting system so that the negative is seen against a surface painted matte white, illuminated by lamps which are invisible to the observer.

The intensity of the illumination may be easily changed by switches which control the number of lamps lighted. There should be good ventilation in any type of illuminator to prevent overheating.

Of late years the tendency has been to eliminate unnecessary illuminators with the attendant glare, confining the equipment to a few lighting units. The Eastman X-ray Illuminator has been designed to furnish an effective illuminator which will fit in with the rest of the furnishings in a well-equipped office or laboratory. Two sizes are available—one to take negatives up to 14 x 17 and the other negatives up to 8 x 10 inches. A blue glass bowl-frosted lamp should be used in this illuminator.

Viewing Dupli-Tized Films

Dupli-Tized films may be viewed while wet by leaving them in the developing hangers.

After they are dry they may be handled and examined with considerably more facility than plates—a whole series being easily manipulated without danger of breakage.

For general viewing, Eastman X-ray Film Viewing clips may be attached rigidly to the view frame.

For stereoscopic viewing the films may be slid into the stereoscopic view box similarly to plates, or an extra sheet of clear glass may be placed in the view box and subsequent negatives slid in behind it.

Film Filing and Storing

Eastman Dupli-Tized X-ray Films are now furnished coated on two types of base—(1) cellulose nitrate base, which was the only type available originally and (2) cellulose acetate, this latter film being known as *Safety* Film.

Eastman *Safety* Dupli-Tized X-ray Films present no greater fire risk than so many paper records and may be filed and stored in any convenient manner. Cellulose nitrate films present a certain amount of fire risk which should be provided for.

The following recommendations apply to cellulose nitrate films only and represent this Company's view as to the proper precautions for minimizing fire danger from these films.

Recommendations for Handling and Storing X-ray Films

(Cellulose Nitrate Base)

General Suggestions

(1) In all rooms where x-ray films are stocked, handled or filed, smoking should be strictly prohibited and conspicuous "NO SMOKING" signs posted.

(2) A metal can (preferably with spring hinged cover) should be provided for all waste negatives and film scrap, and at no time should these be permitted to accumulate and lie around on tables, benches or floor.

(3) It is best, both for the matter of freshness of films and reducing fire hazard, that the stock of unexposed films should be kept at a minimum—the actual quantity depending on the ease of receiving fresh supplies from the dealer or distributor. Such stock should be kept in a cool, dry place out of the way of ordinary room traffic, in a metal box or can. A lead-lined metal box or can is suggested, as this also prevents damage by x-rays.

(4) In rooms where films are filed or handled there should be no flames or any other than standard electrical fixtures. All open lamp bulbs should be protected from breakage by suitable guards. A hand fire-extinguisher should be

in each room where films are handled. Any of the standard approved portable 2½.gallon extinguishers will be satisfactory. Darkroom and other doors should be arranged so as to make egress from such rooms easy. It is also desirable, if possible, to have such rooms protected by automatic sprinklers.

(5) Film negatives should be filed as soon as possible in heavy manila envelopes, either singly or by case, and the filing of these so arranged that it is convenient from time to time to weed out useless negatives. The storage of film negatives in bulk without enclosure should be prohibited, and in all places where films are handled or stored there should be no storage of other inflammable materials and no litter or accumulation of waste paper.

(6) Illuminators should be so designed that the diffusing glass is not hot to the touch and there should be no unnecessary display of film negatives in lighted illuminators. Negatives set up for viewing should be confined to those actually being inspected.

(7) If it is necessary to keep an active file of films for a current period of about a week in the actual x-ray room, these should be kept in a metal container. Such a file should be limited to about 50 lbs. of films.

(8) Films should not be stored in the basement of any establishment.

Suggestions for Filing Bulk Stock of Film Negatives

(1) Where it is necessary to keep the accumulated results of x-ray examinations for a period of months or years, it is obviously necessary to take certain further precautions to reduce fire hazard. In the case of hospitals, where it is usually possible to secure additional space for such a purpose, a suitable room should be set aside for an exclusive and permanent bulk file of all x-ray negatives. Such a room should preferably be located at the top of the building and be of fire-resistive construction. Most modern hospitals have small rooms which could be made into virtually fireproof vaults by a few simple changes. There are only four basic requirements that should be satisfied.

1. The room should be of fire-resistive construction.
2. The room must have a direct outlet to the outer air.
3. There should be a Class B, self-closing fire door at communication to building proper.

4. The room should be additionally protected by automatic sprinkler heads operated from an adequate water supply.

As regards the vent opening in the room, this may be kept covered against the weather by glass or metal, but if such a protective device is used it should be arranged in a sash or so hinged as to open automatically in case of fire. This can be very easily arranged. If the room is not located on the top floor it is desirable in most cases to run a metal vent pipe from the outlet to the roof. The exact size of the vent depends upon the number of pounds of negatives stored and can be determined from the basic requirements that for each 1,000 pounds of film stock there should be 140 square inches of vent. Thus

A circular opening of 13½″ diameter for 1,000 lbs.
A circular opening of 9½″ diameter for 500 lbs.
A circular opening of 6¾″ diameter for 250 lbs.

As a guide in figuring poundage of stock the following table is useful:

1,000—14 x 17 negatives weigh approximately 118 lbs.
1,000—10 x 12 negatives weigh approximately 60 lbs.
1,000— 8 x 10 negatives weigh approximately 40 lbs.
(Other sizes in proportion to area)

Relative to sprinkler protection; if there is no existing independent sprinkler water supply available, it will in a great many cases be acceptable to attach the film room sprinkler to the existing house water supply. There are of course standard specifications covering the necessary sizes of pipes, etc., for water supply to sprinklers, and the advice of someone in touch with these requirements should be obtained.

Where structural changes are necessary, or if it is desirable to partition off a small part of an existing room;—the partition can be most satisfactorily made by using expanded metal lathing on wooden 2 x 4s. There should be about ¾ inch of good grade cement plaster on the metal lathing, and it will of course make a more satisfactory looking room and add to heat insulation by putting this plastered lathing on both the inside and outside of the room. If it is necessary to build a fire-resisting ceiling or floor, the same general type of construction will be satisfactory in most cases.

(2) In case such a room is not available and the quantity

of films does not exceed a reasonable amount, reduction of the fire hazard is assured by the use of proper metal cabinets. These cabinets should be heat-insulated metal safes and be vented to the outside by metal pipes. Suitable safes of this type are available. The quantity of films which can be stored in such a manner is limited to 500 pounds in one safe and 1,000 pounds in two safes in any one room. If reduction of fire hazard only is desired, this type of safe will be generally suitable, but if it is also desirable to save as many negatives as possible in case of a fire, the addition of a suitable sprinkler head in the top of the cabinet is necessary. If a safe containing more than 250 pounds of films is used it should be divided into two compartments—each separately vented. In case of a fire and the flooding of the contents from the sprinkler head, it is possible afterwards to reclaim most of the negatives which will only be wet by soaking them in water as soon as possible. The sprinkler protected safe is the preferable system. In these safes and also in the virtually fireproof rooms previously mentioned, any convenient filing arrangement of films in envelopes may be used.

These suggestions have been carried out by a number of users of x-ray films with excellent satisfaction both as to the matter of safety of negatives, relations with underwriter bodies, and the attendant cost has not been excessive.

As regards old negatives which are no longer necessary, and film scrap; these have a salvage value, this at the present time being 17 cents per pound. Such films should be returned to us at Rochester and the amount of salvage will be promptly forwarded. There are certain shipping conditions necessary to comply with and we will be glad to forward particulars to anyone interested.

As regards special needs of any particular hospital or x-ray laboratory in the matter of film storage, we will be glad to give specific assistance in each case if details of the conditions and number of negatives made in a given time are sent to us at Rochester.

It is strongly urged that these recommendations be adopted as fully as possible, for x-ray films, thus properly considered and handled, present very little risk, and it is the desire of this company to co-operate in every possible way in eliminating any danger at all to hospitals in their use of such films. These suggestions are not to be construed as applying to films in other establishments where the general considerations of use and environment are substantially different from those applying to hospitals.

Lantern Slide Making and Copying

Quite often the roentgenologist wishes to make slides of certain negatives as illustrations to accompany a lecture. With the Eastman Clinical Camera Outfit (described on page 58) this is a simple matter, and, in addition, clinical photographs can also be easily made and slides later made from the negatives. When used for making slides the simplest procedure is to place the negative in the X-ray Illuminator, and by moving the camera to the proper distance the image can be focused exactly on the ground glass to lantern slide size; or, if desired, reduced copies—5x7—may be made, as both 5x7 and lantern slide holders are furnished with the outfit.

The proper developing formulas for the two materials mentioned are given in each package of plates; otherwise, the same general photographic procedure, as previously outlined, will apply, with the exception that a considerably brighter red light may be used with safety in the darkroom. Lantern Slides develop rapidly so that care must be exercised to avoid over-development.

When the slide is dry, a thin sheet of lantern slide cover glass is placed next to the emulsion face, and the two permanently bound along the edges with Lantern Slide Binders. A distinguishing label should then be placed in one corner to mark the proper position of the slide in the lantern.

With this outfit, reduced negatives may also be made of any desired size. For such work Eastman Commercial Films are recommended as having all the ease of handling and filing of paper prints, and with the full rendering power of a transparency, as such film copies faithfully reproduce the quality of the original negatives. In cases where negatives lack contrast Eastman Process Films may be used.

By proper manipulation large stereoscopic negatives may also be reduced to any convenient size, side by side on the same negative. For detailed description of methods recommended in the making of lantern slides, send for a free copy of "Lantern Slides: How to Make and Color Them."

For making contact prints from x-ray negatives a special paper is made—Eastman X-ray Positive Paper.

Price List of X-ray Accessories

Eastman Dupli-Tized X-ray Films, *Super-Speed*

(Cellulose Nitrate Base)

The standard radiographic medium, whether used for direct or intensifying screen exposure. *Uniformly* fast, contrasty and free from fog.

Sizes	Per pkg. one dozen	Per pkg. of 6 dozen
5 x 7	$ 1.45	.....
6½ x 8½	2.30	.....
8 x 10	3.30	$19.10
10 x 12	5.20	30.00
11 x 14	6.60	38.25
14 x 17	10.05	58.05

Eastman *Safety* Dupli-Tized X-ray Films, *Super-Speed*

(Cellulose Acetate Base)

This new film was developed for use in hospitals or similar institutions where it is difficult or undesirable to install necessary systems for storing cellulose nitrate negatives safely. The emulsion is identical with that of *Super-Speed* Dupli-Tized listed above—the only difference in the films being the base. This feature permits filing Safety Films with no more fire precautions than are necessary for the storage of paper records.

Sizes	Per pkg. one dozen	Per pkg. of 6 dozen
5 x 7	$ 1.75	.....
6½ x 8½	2.80	.....
8 x 10	4.00	$23.35
10 x 12	6.25	36.30
11 x 14	7.95	46.35
14 x 17	12.10	70.40

Eastman Intensifying Screen

An improved screen made with a waterproof support and a thin waterproof protective layer over the face, so that it is readily cleaned by simply washing.

The Eastman Intensifying Screen being flexible and with no tendency to grow brittle with age, will stand considerable rough handling and, in addition, can be more easily pressed into contact with the film. Although these screens have excellent service records, their replacement is no hardship because of their low first cost.

PRICES

Eastman X-ray Intensifying Screens	Pair	Single
5 x 7	$ 7.00	$ 4.00
6½ x 8½	11.00	6.00
8 x 10	15.00	8.00
10 x 12	22.50	12.00
11 x 14	29.00	16.00
14 x 17	45.00	24.00

Eastman X-ray Exposure Holders

These holders offer the most convenient and satisfactory method of handling x-ray film during exposure. They eliminate trouble in loading the usual black and orange envelopes. The hinged cardboard with the orange envelope, securely fastened by metal clips, permits the film to be handled with greater convenience during exposure. The holders are well made and with ordinary care will last for a considerable time. They are, of course, lead backed.

Eastman X-ray Exposure Holders

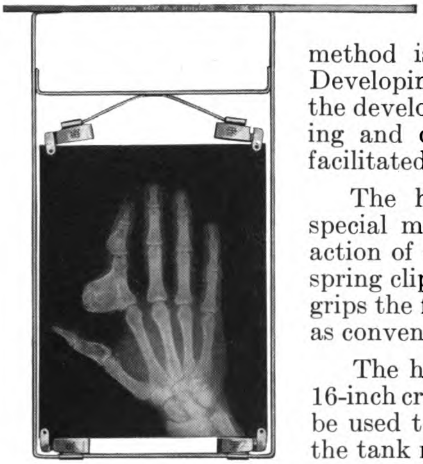
5 x 7	$.10	10 x 12	$ .20
6½ x 8½	.15	11 x 14	.25
8 x 10	.15	14 x 17	.30

Eastman X-ray Film Viewing Clips

These clips offer an efficient means of holding film negatives for viewing. They may be attached to the view frame rigidly or on wires. Films are inserted without need of holding the clip open—a slight pressure releases them.

Eastman X-ray Film Viewing Clips, per doz.	$1.80
Model 2, Spring Roller type, per doz.	1.25

Eastman X-Ray Film Developing Hangers No. 3



The development of x-ray film is made much easier, where the tank developing method is used, by the use of Developing Hangers. Not only the development but fixing, washing and drying are also greatly facilitated by their use.

The hangers are made of a special metal, unaffected by the action of developing solution. A spring clip at each corner securely grips the film so that it is handled as conveniently as a glass plate.

The hangers are made with a 16-inch cross-bar, so that they may be used to the best advantage in the tank method. The prices are:

5 x 7	$ .75	10 x 12	$1.50
6½ x 8½	.85	11 x 14	1.75
8 x 10	1.25	14 x 17	2.00

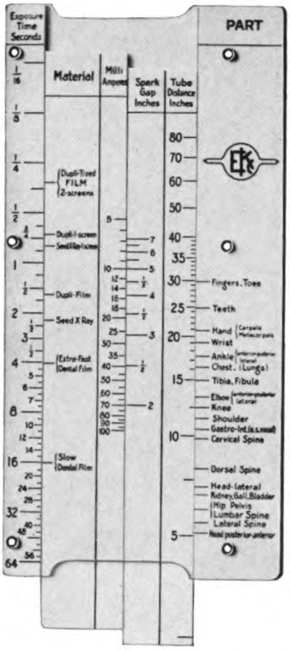
Eastman Dental X-ray Films

These films are furnished in three speeds, designated "Regular," "Extra Fast", and "Radia-Tized." "Regular" and "Extra Fast" are available in two types of packets, as listed below, and with or without non-curling backing. "Radia-Tized" is in one speed and in one type of packet. "Improved" packets contain only clear base film without backing. All packets are thin, round cornered, and lead-backed, yet the entire film is available for exposure.

PRICES

Radia-Tized, Clear base, coated on *both* surfaces, One Speed "A", per box 2 doz. packets	$1.15
Non-Curling, Clear base, Regular "B", Extra Fast "BB," per pkg. 2 doz. prs.	1.40
Improved, Clear base, unbacked, Regular "C," Extra Fast "CC," per pkg. 1 doz. prs.	.70

Order by designating letters.



Eastman X-ray Exposure Rule

A Guide to Correct Exposure.

As the x-ray approaches universal use, standardization of radiographic technique becomes imperative. The Eastman X-ray Exposure Rule is a material step in this direction. It is based upon the results of scientific study in the Research Laboratories of the Eastman Kodak Company, and both its utility and its essential accuracy have been verified in the practice of prominent roentgenologists.

Eastman X-ray Exposure Rule $2.50

Eastman Thermometer

Especially valuable in tank or tray development. Has hook from which it can be suspended and has curved back protecting the tube.

Eastman Thermometer, $ .90

Eastman Lantern Slide Plates—Regular and Slow

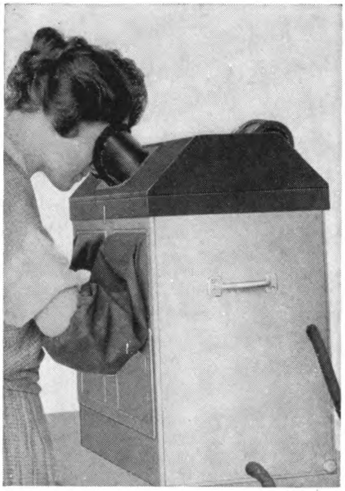
The "Regular" Eastman Lantern Slide Plates produce brilliant slides varying from black to warm black tones from average negatives. The "Slow" Eastman Lantern Slide Plate has a more contrasty emulsion.

Size	Price Per Doz.	No. Doz. in Case
3¼ x 4	$ .50	30

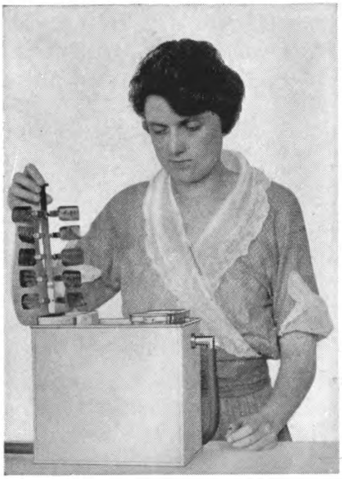
Cover Glass, 35c per dozen.

Eastman Dental Film Developing Cabinet

X-ray work plays such a prominent part in the practice of dentistry today that more and more dentists are desirous of equipping to do it. Many are deterred however, because they have not sufficient office space available for darkroom facilities. It was to meet this condition that the Eastman Dental Film Developing Cabinet was designed.



EASTMAN DENTAL FILM DEVELOPING CABINET



TANK UNIT, EASTMAN DENTAL FILM DEVELOPING CABINET

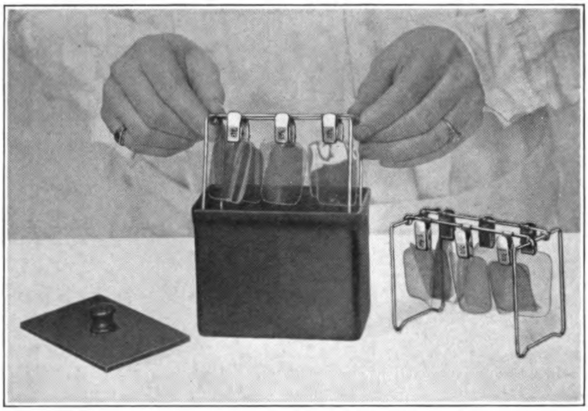
The cabinet is in fact a complete miniature darkroom with tank development, safelight and provision for *circulating* water.

The tank unit consists of an outer metal tank containing two smaller hard rubber tanks with space between for washing. Four developing hangers are included, each holding ten dental films so that facilities are provided for accommodating a large amount of work if necessary.

Although, so compact, this cabinet has every facility for developing, fixing and washing x-ray dental films in a thoroughly satisfactory way. Every dentist can now do his own x-ray work.

Price complete $75.00 or, if desired, the tank unit will be sold separately for $15.00

Eastman Dental Film Developing Tanks



This convenient little tank is made of hard rubber and holds twelve ounces of developing solution. The tank is equipped with a lid also made of hard rubber. A special film developing hanger listed as Eastman No. 5 Dental Film Developing Hanger is supplied for use with this tank as this clip can be used with either regular dental film or the Raper packet.

Eastman Dental Tank Combination, 12 ounce tank and one No. 5 hanger	$1.35
Eastman Dental Film Developing Tank, 12 ounce size tank with lid	.75
Eastman No. 5 Dental Film Developing Hanger, six clips for use in the above tank	.75

Eastman Dental Film Developing Hangers

These consist of a rod on which are clips to hold the film. They may be hung over the side of the developing tank as well as on racks for drying. These hangers have a white celluloid tablet at the upper end of the rod on which the case number can be written.

Eastman Dental Film Developing Hanger, 10 clip No. 2	$1.25
No. 3, short model, 10 clip	1.25
No. 4, 14 clip	1.50
No. 5, six clips, for use in 12-ounce dental film developing tank	.75
Extra clips per dozen	.60

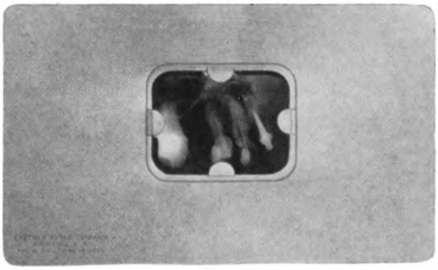
Eastman Dental Film Clips

Individual clips for holding a single film can be suspended on the side of the tank. These clips each have a white celluloid tablet on which a record may be written.

Price, per dozen, $1.10

Eastman Dental Film Mount

The new Eastman Dental Film Mount, offers a most effective and satisfactory method of holding any type of No. 1 films. The negative is simply slipped into place, and is held securely and neatly framed.



Price (per 100) Single opening $2.00
We do not furnish imprinted mounts

In addition to the single mounts the Eastman Dental Mounts are furnished for two films in the horizontal position, two films in the vertical position and multiple film mounts with the anatomical chart holding 10, 11 and 14 films. The multiple mounts are, of course, ideal for keeping a complete record of all the teeth.

A special multiple mount with five openings for use with Bite-Wing Dental Film has been designed and is now available.

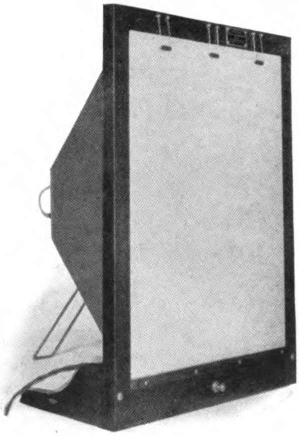
The Eastman Multiple Dental Film Mounts, per 100:

two openings horizontal	$3.00
two openings vertical	3.00
five openings for use with Bite-Wing Film	6.00
ten openings	9.00
eleven openings	11.00
fourteen openings	14.00

Note: These mounts are furnished without any printing except for the anatomical chart and proper spaces for the filling in of clinical data. We do not furnish imprinted mounts.

Eastman X-ray Illuminator

14x17 Size



This viewing unit is a necessity in the x-ray department.

Light is furnished by a single lamp, yet illumination is ample and evenly diffused by flashed opal glass. Clips are provided for holding films. Designed so that units will fit together side by side.

Mahogany finish only.

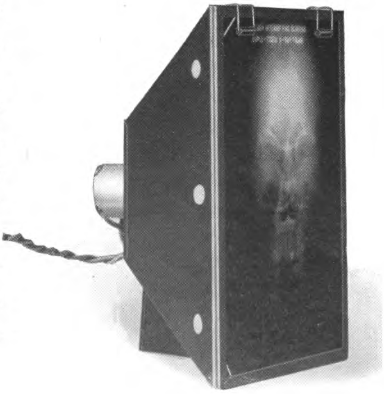
100-watt bowl-frosted blue Mazda lamp is recommended.

Price $16.50

Eastmam X-ray Illuminator

8 x 10 Size

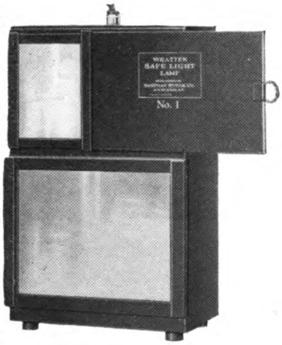
The smaller size is of similar design to the 14x17 size but is made of metal. Careful attention has been paid to even distribution of the light as well as ventilation. The 8x10 illuminator uses a 25-watt bowl-frosted blue Mazda lamp yet the flashed opal glass diffuser is scarcely warmed. Roller clips hold the film flat.



Price $6.00

Safelights

Wratten Safelight Lamp



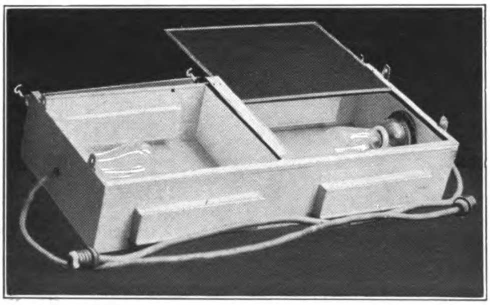
Affords ample light plus real safety. The soft, indirect light relieves eye strain, while the safelight itself transmits the greatest volume of light that can be used with safety. Series 2 Red Safelight is furnished unless otherwise specified.

Wratten Safelight Lamp, No. 1, as above	$10.00
No. 2, without slide for white light	8.00
Series 4 Safelight (green), 8x10	1.25

Indirect Light-Boxes for Darkrooms

These boxes suspended from the ceiling provide ideal illumination. They are made of metal, correctly ventilated and finished in white enamel. Fitted with cord and plug.

Supplied either single or double for either one or two 10 x 12 Wratten Safelights. Specify number of safelight when ordering. Lamp bulbs not furnished.



THE PRICE

Single (without safelight or bulb)	$ 9.00
Double (without safelight or bulb).	18.00
Wratten & Wainwright Safelight, any series, 10 x 12, each	1.75

Brownie Safelight Lamp

Slightly larger than the electric bulb it holds, the Brownie Safelight Lamp screws into an electric socket which may be conveniently situated close to the place where the work is to be done.

Both safelights are the regular Series 1. Series 2, deep red, or 4, green, will be supplied if specified. A 10-watt Mazda lamp is used, but is not supplied.

Brownie Safelight Lamp	$1.75
Extra Circular Safelight (any series), each . .	.25
Extra Side Safelight (any series), each	.40

Eastman Safelight Lamp

This convenient darkroom lamp hangs from an electric cord or fixture and throws the light from a 10-watt bulb directly downward over the work table. Supplied with a 5 x 7 Safelight Series 2.

Eastman Safelight Lamp, without bulb	$3.00
Extra Safelight, any series	.75

Kodak Safelight Lamp

The Kodak Safelight Lamp is ideal for all darkroom uses. Unless otherwise specified the lamp is supplied with a 5 x 7, Series 2, red safelight. Safelights of other series may be obtained if specified.

Supplied complete, excepting electric bulb, including besides the safelight, four feet of electric light cord with socket.

Kodak Safelight Lamp . .	$3.50

Eastman Clinical Camera

CAMERA READY FOR LANTERN SLIDE MAKING

For depicting surface lesions, abnormalities, pathological specimens, operating technique and similar subjects the photograph gives a permanent and faithful record of conditions as they exist at the time, and is so simple of interpretation as to need little written explanation.

Provision is made for photographing to a definite scale—by setting the indicator to the desired scale and simply moving the camera back and forth until the subject is in focus, a series of photographs can be made to show a changed condition over a period of time.

Lantern slides and enlargements can be made from negatives made with the Clinical Camera as well as from radiographs.

CAMERA SHOWING TILTING TOP AND STAND

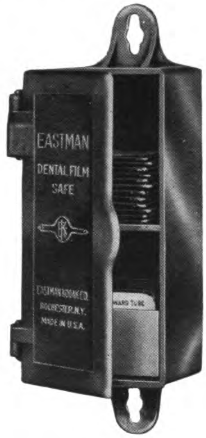
Eastman Clinical Camera including 5x7 Camera, Kodak Anastigmat Lens *f*.7.7 in No. 2 Kodamatic Shutter. One double 5x7 cut film or plate holder. One Lantern Slide Back and one Enlarging Back. Collapsible Stand with tilting top. Two Eastman Floodlights.

Complete	$180.00

Parts Supplied Separately

5 x 7 Camera only, without lens	$70.00
Kodak Anastigmat Lens *f*.7.7 fitted to No. 2 Kodamatic Shutter	37.50
Camera Stand	22.00
Lantern Slide Back	14.00
Enlarging Back	14.00
Eastman Floodlight . . .	20.00

Eastman Dental Film Safe



This convenient little metal cabinet has been designed to meet the needs of dentists. It may be attached to the wall or the apparatus itself, furnishing a satisfactory means for keeping dental film packages from x-rays without any undue trouble.

Protection is equivalent to $\frac{1}{16}$ inch of pure lead.

Sizes—outside—2⅛ x 1¾ x 4¾ inches.

Capacity—two separate compartments, each holding 2 dozen dental film packets.

Price $3.00

Eastman X-ray Developer Powders

Eastman X-ray Developer Powders are especially prepared for x-ray development and offer the most economical and convenient means of obtaining the best results in either tank or tray development of films or plates.

They cost no more than developers prepared from formulas and their use precludes the possibility of waste through faulty preparation of solutions.

No. 2 package of 6 powders, each sufficient to prepare 12 ozs. of ready-to-use solution . . .	$ .60
No. 3 package containing sufficient powder to prepare one gallon of ready-to-use solution . .	.85
No. 4 package containing sufficient powder to prepare 5 gallons of ready-to-use solution . .	3.50

Eastman X-ray Fixing Powders

These powders are the final step in the standardization of development of x-ray films or plates. They are ready for use with the addition of water and the solution thus obtained is clear and colorless. They combine fixing with maximum hardening. Packed in convenient units to make tank re-charging easy.

No. 3 package sufficient to prepare one gallon solution	$ .60
No. 4 package sufficient to prepare five gallons solution	2.50

Elon

A vigorous developing agent of excellent keeping qualities, for use in combination with Hydroquinone.

1 ounce bottle	$ .52
¼ pound bottle	1.60
½ pound bottle	3.08
1 pound bottle	6.00

Eastman Tested Chemicals

Prepared with special reference to x-ray work.

		In Pacific Coast Territory
Hydrochinon, 1-oz. can	$ .22	
Hydrochinon, 1-lb. can	2.47	
Sodium Carbonate (E. K. Co.), 1-lb. bottle	.40	$ .43
Sodium Carbonate (E. K. Co.), 5-lb. bottle	1.35	1.50
Sodium Carbonate (E. K. Co.), 1-lb. can	.27	.29
Sodium Carbonate (E. K. Co.), 5-lb. can	1.10	1.20
Sodium Sulphite (E. K. Co.), 1-lb. bottle	.45	.48
Sodium Sulphite (E. K. Co.), 5-lb. bottle	1.40	1.55
Sodium Sulphite (E. K. Co.), 1-lb. can	.28	.30
Sodium Sulphite (E. K. Co.), 5-lb. can	1.20	1.30
Thiosulphite of Soda, (Hypo) Granular, 1-lb. carton	.18	.19
Velox Liquid Hardener, 8-oz. bottle. .	.35	
Sodium Bisulphite, 1-lb. bottle . . .	.40	
Potassium Bromide, Granular, 1-oz. can	.15	
Potassium Alum, Powdered, 1-lb. carton	.20	.22
Eastman Reducer, per carton of 5 tubes	.50	

All prices subject to change without notice

EASTMAN KODAK COMPANY,
Rochester, N. Y.

Eastman X-ray
Developing and Fixing Powders

Packed in convenient sizes for either Tank or Tray use, Eastman X-ray Developing and Fixing Powders assure you of the purest chemicals, properly and accurately compounded. Correct development and fixation are half of making a correct radiograph.

They are tested and you know they're right

Eastman Kodak Company
Medical Division Rochester, N. Y.

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